Preliminar Propagation and MIMO Experiments in Train Tunnels at 5.8GHz

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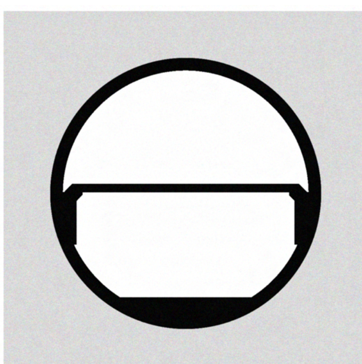
Introduction

In [1] and [2] a set of tools were presented in order to characterize radiowave propagation in train tunnels at 5.8GHz. An experimental campaign was carried over in a straight tunnel at Barcelona L2 Metro and results were presented and compared with theoretical results. In this paper, results of a new measurement campaign at 5.8GHz for a different tunnel geometry are presented. A curved tunnel section has been measured for SISO and 2x2 MIMO schemes to provide more accuracy for radiowave propagation characterization in tunnels and quantify the improvement attained when MIMO technologies are used.

Measurements Environment and Experimental Setup

The experimental campaign was done at Barcelona L9 Metro. The cross-section geometry of L9 differs notoriously from the scenario described in [2]: a 6m-radius circular shape split in two halves that can be observed in Fig.1. Measurements are taken in the lower half of the tunnel, in a right-bended stretch of 300m and curvature radius of 288m.



(a) L9 cross-section scheme

(b) L9 lower section

Figure 1: L9 Tunnel

Setup for the SISO experiment is described in [2]. Tx is placed 2.3m left from the tunnel axis at 2m height.Rx is aligned with the Tx at the beginning of each set of measurements (HH,VV and VH polarizations). Fig.2 shows the MIMO setup. Two Software Defined Radio (SDR) laptop-controlled cards are used as Tx and Rx respectively. Both transmitting and receiving antennas are composed of two resonating square patches in a 1x2 array configuration, connected to each SDR

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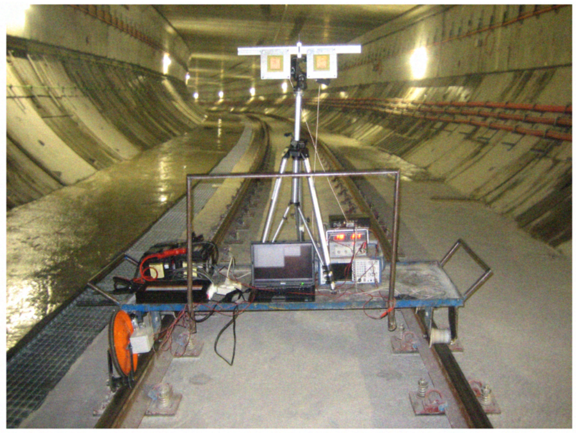
card, centered 1.7m left of the tunnel axis, 1.4m height. The Tx generates two delta-tones centered around 5.8GHz frequency-spaced 10KHz. The Rx is mounted on a sliding platform manually pushed and captures data every 0.25m. Again, three sets of measurements were captured. Polarization for Tx and Rx is identical for each set: first both antennas of each array operate in V polarization (VV), afterwards in H polarization (HH), and finally one antenna operates in V and the other in H (VH).

(a) MIMO transmitter



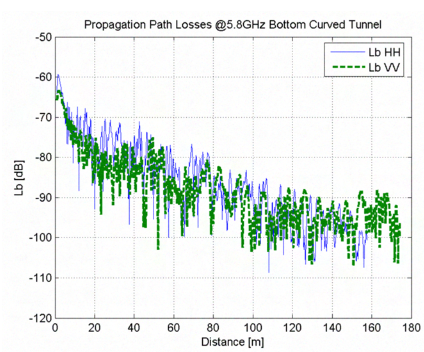
(b) MIMO receiver

Figure 2: MIMO setup

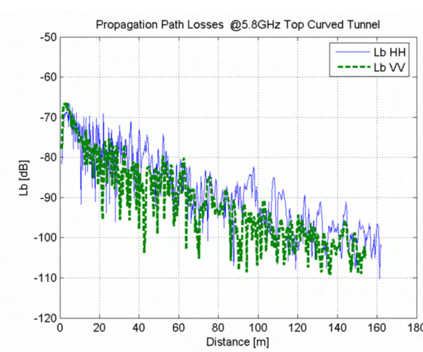
Measurement Results

In this section the propagation path loss curves and the preliminar MIMO results are presented. The propagation path losses are presented in Fig. 3 where the same behaviour observed at [2] for curved tunnels is present at the curves. These propagation path losses curves allow to analyse the behaviour of the MIMO set-up in terms of received power for different configurations.

The Fig. 4 summarises the singular value behaviour along the bottom section of



(a) Bottom section of the tunnel propagation path losses

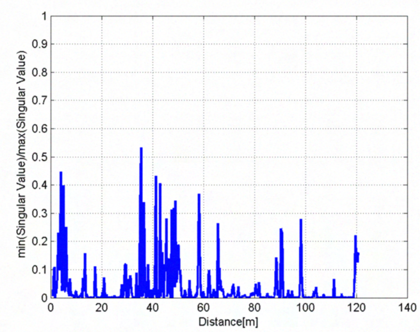


(b) Top section of the tunnel propagation path losses

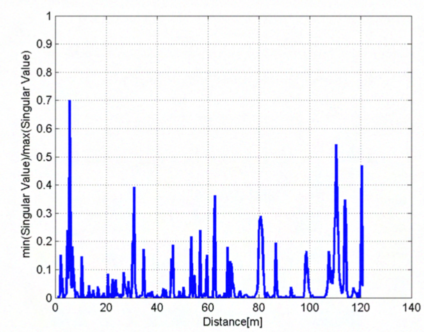
Figure 3: SISO propagation path losses at 5.8GHz

the curved tunnel showing the singular value relation $\frac{min(\sigma_i)}{max(\sigma_i)}$ for different antenna

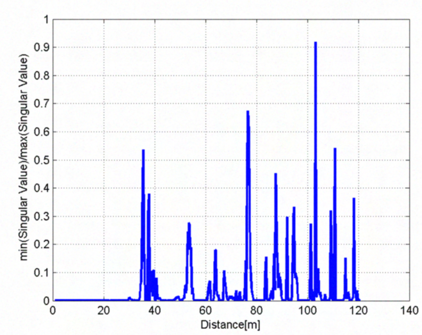
spacing (λ, 3λ) and different polarisation (VV and VH) which is an example of the expected results [3]. In this curve σ_i are the set of singular values of the normalised channel matrix. With this representation a ratio of 1 means equal singular values and a full availability of independent channels. On the other hand, a ratio of 0 means the existence of a single channel.
In Fig. 4 erratic behaviour of the singular value relation can be observed at VV and VH polarisation with λ and 3λ antenna spacing. However, the VV configuration with 3λ antenna spacing shows a less erratic behaviour in the singular value relation due to a lower influence of the deep fading over this transmitter/receiver configuration. This observation leads to a preliminar conclusion about the MIMO capacity advantages in subway tunnels based on the results presented at [4] where the depolarisation in arched tunnels is studied. Note that analysis has been performed with a equal distributed transmitting power.



(a) $\frac{min(\sigma_i)}{max(\sigma_i)}$ for VV configuration with λ antenna spacing



(b) $\frac{min(\sigma_i)}{max(\sigma_i)}$ for VV configuration with 3λ antenna spacing



(c) $\frac{min(\sigma_i)}{max(\sigma_i)}$ for VH configuration with 3λ antenna spacing

Figure 4: $\frac{min(\sigma_i)}{max(\sigma_i)}$ for different antennas polarisation and antenna spacing

Conclusions

At this paper, a complete set-up to subway radio propagation measurement at L and C Band is presented. This set-up has been tested at a real subway tunnel with a special structural characteristics allowing propagation path loss measurements and MIMO analysis in order to study the best system configuration working in subway

environments.
Therefore, the next step is to present a new measurement camping where a complete characterisation of the diversity possibilities inside a straight and curved tunnel will be provided. This new campaign will take place at the L9 Barcelona Metro Network new facilities.

Acknowledgments

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